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Pro-Poor Electricity Provision

The Evidence of Benefits for Poor People of Electricity Provision: Scoping Note and Review Protocol

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August 2013

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EVIDENCE FOR BENEFITS OF POOR PEOPLE OF ELECTRICITY PROVISION

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Introduction

As part of a larger Accountable Grant from the UK Government's Department for International Development (DFID), the Institute of Development Studies (IDS) is to conduct a review of the evidence that investments in electricity generating capacity have benefits for poor people, and what factors influence that relationship.

DFID is increasingly involved in interventions in the electricity sector, in part because of increased interest in renewable energy under the imperative to mitigate climate change. However, in order to ensure that these interventions are also effective in benefiting poor people, the Department is interested in developing a better understanding specifically of how investments in low carbon electricity generating capacity may benefit poor people, and what factors affect the relationship between capacity and poverty reduction.

At one level, the relationship between electricity, economic growth and the elimination of poverty is obvious. At the aggregate level, no country has achieved a high level of per capita income and welfare without a functioning electricity system.[1] At the level of individual households, as discussed in more detail below, access to a reliable supply of electricity by poor households is thought to contribute significantly to overcoming a number of barriers, including: limited opportunities for children to study; severe constraints on economic opportunities; negative health effects via inability to store food safely; and constraints on the ability to access information via TV, radio and mobile phones. Lack of access at the community level may have negative effects on the provision of services, including health, education and pumped water. Finally, limited access and poor reliability of supply more widely across the economy may prevent the reduction of poverty through constraining economic growth.

However, the evidence for the exact relationships between the provision of electricity on the one hand and the reduction of poverty on the other are not as well understood as they could be. These relationships are likely to be complex, may work through both direct and indirect routes and will be mediated by a number of other factors. Also, causality is not clear because more income per capita implies more electricity usage and access. Although there are some existing reviews of particular aspects of the relationship between electricity and poverty, an up-to-date, rigorous assessment of the evidence base designed to inform DFID's programming is absent.

The objective of the review to be undertaken by IDS is to assess the extent and quality of the evidence base for the relationships between low carbon electricity capacity and benefits for poor people. It will inform the development of indicators and methodologies to be used in the business case for investments. This review is being undertaken in parallel with a power systems modelling element by the School of Engineering and Computer Studies at the University of Durham.

The proposed review is not tied to any rigidly defined methodology,[2] but does draw on the approach of evidence-based policy, especially the elements of expert review of the study and transparency in method.[3]

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[1] There is a strong log-linear aggregate cross-sectional relationship between per capita commercial energy consumption and per capita GDP, for example (Modi *et al*. 2005: 18).
[2] DFID's Research and Evidence Department defines a specific type of review (a "systematic review") as satisfying certain criteria and being accredited and reviewed by certain bodies, i.e. the Cochrane Collaboration or 3ie (who work jointly with the International Development Review Group of the Campbell Collaboration). This proposed review is not a systematic review in this sense.
[3] This approach follows that taken by the UK Energy Research centre reviews, for example.

This document sets out the background and context for the study, and the approach taken. It delineates the boundaries of the study and highlights some of the relevant issues and the types of evidence available. It identifies the different kinds of electricity interventions and the kinds of developmental outcomes to be considered. The details of the proposed approach may subsequently be refined in consultation with reviewers and other stakeholders.

1 Background

Electricity is a universal facilitating technology for modern economies, being the most flexible form of energy. Provision of electricity, along with other forms of infrastructure, was a focus for early development efforts, and all developing countries have some form of electricity grid[4] with large-scale generation. However, in many countries, a combination of institutional problems and the economics of expanding grid infrastructure to remote and sparsely populated areas have meant that only part of the population is served by the grid. The International Energy Agency estimates that around 70 per cent of the population in sub-Saharan African does not have access[5] to electricity (higher in some countries), while in rural India there are still 380 million people without access (OECD/IEA 2010).

This may sometimes be for political reasons, but it is frequently for economic reasons, either because of the high cost of reaching remote communities with high-voltage networks or because policy favours prioritising areas where the returns to electricity infrastructure are likely to be highest, which tend not to be the poorest areas. Where electricity is available in a locality, actual connection and use often tends to be biased against poor households and rural households. Finally, in many countries, where households and enterprises are grid connected, supply can be intermittent and unreliable.[6]

After a number of years in which electricity provision slipped down the list of priorities for donors and governments (especially in Africa and South Asia), it is now receiving more attention. A 2009 World Bank assessment of infrastructure needs in Africa, for example, called for investment of $930 billion over ten years, of which nearly half should be in the power sector (World Bank 2009). This renewed interest is in part because of the emergence of climate change as a major problem, and interest in forms of low carbon development, in which low carbon energy plays a major role. There is now considerable interest in catalysing investment in low carbon electricity generation, especially through renewable technologies, to help developing countries avoid 'lock-in' to high carbon growth paths (IEA 2010; Unruh 2006). In addition, the view that the provision of modern forms of energy is essential for the delivery of the Millennium Development Goals (MDGs) has steadily grown over the last decade. The review that we scope here will help assess the evidence base for that view.

The combination of objectives of achieving universal access to modern forms of energy (which includes electricity), and increasing low carbon energy capacity and greater energy efficiency in developing countries come together in the call for Sustainable Energy for All, with 2012 being the UN's Year of Sustainable Energy for All.[7]

As a result, bilateral donors and multilateral development banks are now seeking to put an increasing amount of resources (both directly, and indirectly through leveraging private finance) into investment in electricity generation and access in low-income countries. This includes the UK's International Climate Fund (ICF), which will disburse £2.9 billion over

[4] The term "grid" is commonly used to denote a high-voltage transmission network and distribution networks that step down voltages to user levels.
[5] There is no universally agreed and accepted definition of access to electricity. The IES defines it as having "a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average". In practice, most studies focus on simply gaining a connection, and less on reliability or peak demand. The definitional issue is discussed further in section 3 below.
[6] Data on reliability of electricity supply in many developing countries is patchy. As discussed below, the review will assess the extent of the data gap.
[7] http://www.sustainableenergyforall.org/ (accessed 9 July 2013)

the period 2011-14, with 30 per cent (£870 million) allocated to low carbon development, of which a significant share may be spent on low carbon electricity infrastructure.[8]

The ICF is run jointly by DFID, the Department of Energy & Climate Change (DECC), the Department for Environment, Food & Rural Affairs (DEFRA) and the Foreign & Commonwealth Office (FCO). One major issue for DFID is to ensure that its ICF-funded electricity investments not only help to mitigate climate change by reducing carbon emissions against business-as-usual, but also benefit poor people more directly through greater electricity use or through growth in the wider economy or both. To address this issue, the Department is developing methodologies for the planning of investments and indicators for assessing them, and wants to ensure that these methodologies and indicators are based on sound evidence.

The proposed review will aim to:

- Draw conclusions about how best to maximise the impacts on poverty reduction of investment in low carbon electricity generating capacity.
- Contribute to clarifying the relevant conceptual, definitional and methodological issues in assessing the relationship between investing in renewable electricity generating capacity on the one hand, and benefits for poor people on the other.
- Assess the methodological challenges and solutions to accurate estimation of impacts.
- Identify assumptions made in studies and the reasons for conclusions reached.
- Identify gaps in data and research.

[8] ICF Implementation Plan 2011/12-2014/15

2 Review questions

The review aims at contributing to an answer to the question:

Under what conditions does adding low carbon electricity generation capacity (both on and off-grid) lead to development benefits for poor people?

This overall question can be broken down into a number of sub-questions. The first two questions apply particularly to grid systems. The subsequent two questions apply both to grid and off-grid electricity consumption.

2.1 Under what circumstances does investment in low carbon generating capacity increase the number of electricity consumers, the consumption of existing consumers or the reliability of supply?

In the case of off-grid systems with a single power source, it is fairly straightforward to link investment in low carbon capacity with electricity consumption by end users (poor households). However, DFID is also interested in generating a methodology and related indicators that allow it to assess how far poor households may benefit from the addition of low carbon or 'clean' electricity generating capacity to grid systems in developing countries.

This is a more complex issue. Currently, the draft ICF key performance indicators distinguish between the level of installed capacity of clean energy and the number of people with improved access to clean energy. At present, the latter indicator applies only to off-grid interventions. The proposed review, along with related modelling from Durham University, is intended to inform the development of a methodology to measure the number of individuals who are able to consume clean energy from on-grid projects.

Electricity is a system rather than a fuel. Supply of electrical power to an end user requires generation, transmission and distribution.[9] A reliable supply of power requires generating capacity to match demand at all times, including at times of peak demand. In this context, peak capacity means that capacity that is reliably available. In a large system (i.e. regional or national grid), to ensure reliability, an excess of available unused capacity over expected peak demand is required. Some types of power generation, including fossil fuel generation using gas, oil or coal fired thermal plants, are known as 'dispatchable' as they can be ramped up and down to follow daily or seasonal changes in demand. The power output of nuclear plants can also be varied,[10] but this is costly, so nuclear is often run at base load (i.e. at a constant output). Dispatchable power sources may not always be available, because of planned maintenance downtime or faults, and in large grid systems their contribution to the peak capacity of the system is 'de-rated' by a small proportion to reflect this.

Renewable electricity technologies vary in whether they are dispatchable. Biomass, hydro and geothermal are dispatchable, but solar PV and wind vary with the strength of the wind and sun, and are known as 'intermittent' power sources. Without storage (which remains prohibitively costly at grid scale), they cannot be dispatched at peak times and so

[9] In very small-scale technologies (such as solar photovoltaic products or on-site systems) these elements are collapsed into one.
[10] In France, the output of nuclear plants is to an extent varied over the course of a few days, but this practice requires greater maintenance of the reactor cores.

they cannot be regarded as adding their rated (i.e. maximum output) capacity to the peak capacity of the system. They are thus also de-rated, but to a greater extent than dispatchable power sources.[11] In conventional, demand-following grid electricity systems, a large proportion (i.e. above 20 per cent) of intermittent renewable generation starts to pose problems in terms of the use of dispatchable power plants to balance supply and demand. Few developed countries and no developing countries yet approach this level of wind at present, however.

A conventional measure of the expected reliability of an electricity system is the excess of total de-rated generating capacity in a system over expected peak demand, known as the (planning) capacity margin. Standard practice for grid systems in developed countries is to maintain a capacity margin of around 15 per cent. As the capacity margin in a system falls below around 10 per cent of peak demand, the reliability of supply begins to deteriorate,[12] with an increased likelihood of load shedding in the form of unplanned blackouts (interruptions in supply), brownouts (voltage drop to avoid blackouts), or planned blackouts to avoid brownouts. In many developing countries, reliability problems arising from insufficient capacity margins are common and involve considerable costs for users of electricity.[13]

In principle, an addition to electricity generating capacity within a system should provide some combination of improvement to the reliability of electricity supply, a greater number of electricity consumers, or increased peak consumption of electricity per user, as long as that addition exceeds any increase in total peak demand (see Annexe 1).

However, a key factor affecting the contribution of new generating capacity to these outcomes is the state of transmission and distribution (T&D) networks. Many T&D networks have points where the flow of power from regions of excess capacity to regions of excess demand is constrained by the capacity of the network. Thus the impact of adding new capacity on reliability, consumption and the number of potential consumers depends partly on its geographical location in relation to centres of demand and the ability of the existing network to deliver power from the new plant to those centres. The reliability of supply also depends more generally on the state of networks, especially distribution networks, how well maintained they are and how resilient to events like storms. Where blackouts are caused mainly by network faults, adding new generating capacity will not help.

Total demand, access and available capacity in electricity systems in many developing countries are constantly changing, which means that it is not clear what the counterfactual is, and comparisons have to be made with the state of the system before the intervention. It also means that the effects of an intervention may change over time. For example, in 2000 the Asian Development Bank co-financed the construction of a 450 MW gas-fired turbine outside of Dhaka in Bangladesh. The aim of the project was to reduce power shortages and load shedding. The project was large by Bangladeshi standards – representing 9 per cent of national generating capacity – and initially had a significant effect on improving reliability and expanding access. However, the lack of further investment in new plant since, within a context of rapidly growing demand for electricity, means that 'the load shedding and supply problems that were a major reason

[11] For example, in assessing planning capacity margins in the UK, DECC de-rates on-shore wind to about 25-30 per cent of its peak capacity, and solar PV to about 10 per cent of its peak capacity.
[12] There are a range of different commonly used measures of poor reliability of supply, including loss of load probability, loss of load expectation and expected unserved energy.
[13] The ability of system operators to manage load shedding spatially also means that users in politically or economically more marginal areas tend to have more unreliable supply than, for example, the centre of large cities. In some places, poor reliability of national electricity systems has led many users, especially industrial and commercial users, to install on-site generation at their own expense as an alternative. For example, in India, where reliability is a chronic problem, such on-site 'captive power' constitutes almost 15 per cent of total capacity.

for undertaking the project in the first place have re-emerged and are now hindering Bangladesh's economic performance' (ADB 2009).

In summary, the potential for the addition of new low carbon generating capacity to a underpowered grid electricity system to increase the number of electricity consumers, to increase the consumption of existing consumers or to improve the reliability of their supply will depend on a number of factors, including:

- The type of low carbon generation (e.g. intermittent vs dispatchable).
- The location of the plant in relation to centres of demand and the capacity of the T&D network.
- The state of the T&D network more generally.
- The reliability of the electricity system.
- Changes in average electricity consumption.
- Changes in the number of consumers, including not only legal network extension but also illegal connections (which are common in developing countries).

Good data on some of these factors, especially the state of networks, reliability, and the number of consumers, may not always be available.[14] The review will assess the extent of the data gap.

Power systems planning models (such as WASP[15]) are used to explore the expected outcomes of investments in new generating capacity in particular systems in particular countries. The modelling approach involves specifying parameters reflecting the configuration of networks and making assumptions about trends in the growth of demand.

The challenge in developing a methodology for assessing the potential benefits of adding capacity for use in DFID business cases lies in moving from the modelling of particular cases using a detailed, technical tool to a simpler assessment that can be applied more generically.

Such an assessment methodology will need to be based on power system modelling, and is being developed by Dr Chris Dent, School of Engineering and Computer Sciences at the University of Durham, in a parallel exercise to this review.

2.2 Under what circumstances does the extension of networks ('electrification') lead to more poor households consuming electricity?

A key variable of interest to DFID is the extension of electricity consumption to poor households which previously did not have access to it. Whether or not the addition of new capacity leads to this outcome clearly depends on whether complementary grid extension investments are undertaken in the particular country involved.[16]

However, while this is a necessary condition, it is not sufficient. This is because, while there are exceptions, better off households and communities very often gain access to electricity supply before poor households (World Bank IEG 2008: 4). This is sometimes a product of explicit policy (e.g. since a critical study in 1995 (World Bank 1995), the World

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[14] For example, for many countries the only source of data on the reliability of electricity supply are the World Bank's Enterprise Surveys

[15] http://www-pub.iaea.org/MTCD/publications/PDF/CMS-16.pdf (accessed 20 July 2013)

[16] In the absence of such programmes, it is possible that new capacity could enable more illegal connections by poor households. Theft of electricity can be extensive – in Uttar Pradesh, for example, about a third of electricity is unaccounted for (Golden and Min 2012). While part of this is explained by T&D losses, it also reflects widespread illegal use.

Bank has prioritised electrification in areas where returns to investment will be highest, which tends to drive investments towards better off areas of a country). Even where electrification takes place in poorer areas and communities, very often it is wealthier households which self-select to connect to a distribution network, because poorer households cannot afford to do so. There are exceptions to this pattern (e.g. South Africa – see Dinkelman 2008), but it is fairly common.

Some empirical evidence on the relationship between the extension of networks and electricity consumption by poor households will come mainly from evaluations of electrification projects from a wide range of organisations, including multilateral development banks (e.g. ADB 2010), bilateral donors (NORAD 2008), and NGOs.

In addition, there may be further empirical evidence on the broad relationships between the growth of capacity, the extension of networks, and electricity consumption by poor households in developing countries that have completed, or nearly completed, the electrification process (for example in China, South East Asia or Latin America) (e.g. Pan *et al*. 2006).

2.3 What are the poverty outcomes of poor households' electricity consumption?

The link between electricity use by poor households and poverty reduction is often asserted, appearing, for example in the Johannesburg Plan of Implementation arising from the World Summit on Sustainable Development and more recently in Sustainable Energy for All documentation (e.g. Birol and Brew-Hammond 2012).

However, it is important to clarify what is involved in the supply and use of electricity, not least because the commonly used term 'access' is not clearly defined, and hides a number of distinct separate aspects of the consumption of modern energy services by households.

Direct benefits for poor households depend on electricity supply being available (i.e. in the form of a home system, or the existence of a mini-grid or a distribution network in the community) and accessible (i.e. poor households can physically connect and pay any costs of connection and supply). However, beyond this, a simple measure of 'access' to electricity glosses over variation in the type and quality of supply. There can be large differences in the level of power being delivered, from maybe a 50 watt solar home system, up to a grid-connected source with unlimited power. There can also be widely varying experiences in the reliability of supply. In many cases, power may be available only for a few hours a day on a regular basis, in other situations supply may be interrupted in an unpredictable way.

Once delivered to an end-user, electricity can be regarded as an intermediate or facilitating technology which produces both direct and indirect benefits (Cook *et al*. 2005). The key route by which electricity produces benefits is by providing electrical, mechanical and thermal 'useful work' (Ayres and Warr 2005) through complementary electricity-using technologies (Committee on Electricity in Economic Growth *et al.* 1986). Such work is also sometimes referred to as energy services.

In the case of direct benefits for poor households, important electricity-using technologies may include electric lighting, batteries and chargers for mobile phones, TVs and radios, fridges, pumps and other agricultural and on-agricultural machinery etc. (e.g. Practical Action 2010, 2012). These technologies produce useful work or services that are both final consumption and intermediate consumption (Prud'Homme 2005). Services provided by electricity and a complementary technology can directly improve welfare (for example, by safely storing food in a fridge which prevents illness or by providing entertainment via TV). But it can also raise the productivity of labour and capital (for example, through powering agricultural processing machinery), and reduce transactions costs, sometimes radically so, leading to higher incomes for the poor.

A number of reviews of evidence (including some commissioned by DFID) on direct links between electricity consumption and development benefits for poor households do exist (e.g. Suarez 1995; Brenneman and Kerf 2002; AEA Technology 2003; Willoughby 2002; World Bank IEG 2008; Bernard 2010). These have pointed to two important dimensions of the impacts of electricity use on poor households.

One is that poor households very often only use electricity for a few consumption-related purposes, especially early on after gaining access, and their consumption is often quite low. Thus a review of the benefits of rural electrification in 2008 by the World Bank's Independent Evaluation Group (2008: xvi) notes that: 'Lighting and TV account for at least 80 percent of rural electricity consumption and thus the bulk of the benefits delivered by electrification.' By contrast, wealthier households are more likely to use electricity for productive purposes (e.g. water pumping for irrigation, agro-processing). Generally, rural households and communities use electricity for a greater range of purposes in middle-income countries than in low income ones. This difference is found because households need to acquire the electricity-using technologies required to derive energy services, and poor households at least initially cannot afford them.

A second important finding is that the realisation of benefits for individuals in poor households will also depend on a large number of contextual factors, including gender relations,[17] multiple other factors determining livelihood opportunities (such as access to markets, human capital, other infrastructure, security of property rights etc. – UNDP 2012), and the availability of complementary technologies.

An important aim of this review will be to update and consolidate the evidence on these two issues. In the second of these two areas, we will assess whether the evidence base is sufficient to draw out conclusions about a core set of institutional enablers that maximise the benefits of direct electricity consumption by poor households and individuals.

2.4 Do improvements in electricity supply lead to effects that can indirectly benefit poor households benefit?

As noted above, both because of placement bias and self-selection, in many contexts better off households or enterprises gain access to electricity supply before poor households (World Bank IEG 2008: 4). In principle, however, poor households may still benefit indirectly through spill-over effects.

One of these effects is economic growth in the wider local, regional or national economy, generated through increasing the productivity of both labour and capital, again by the introduction of electricity-using technologies producing useful work (Committee on Electricity in Economic Growth 1986; OECD 2006). This route assumes that increasing the reliability and/or the availability of electricity will induce higher levels of investment, from both domestic and foreign sources (Jahan and McCleery 2005). There are differing views on whether the effects of a given level of investment in infrastructure (such as

[17] There is some evidence that gender relations themselves may be affected by the provision of electricity, although the ultimate impacts on the relative welfare of women in poor households are not clear (Clancy *et al.* 2011; Winther 2008)

electricity) will be greater in cases where existing provision is low or in cases where existing provision is high (Straub 2008).

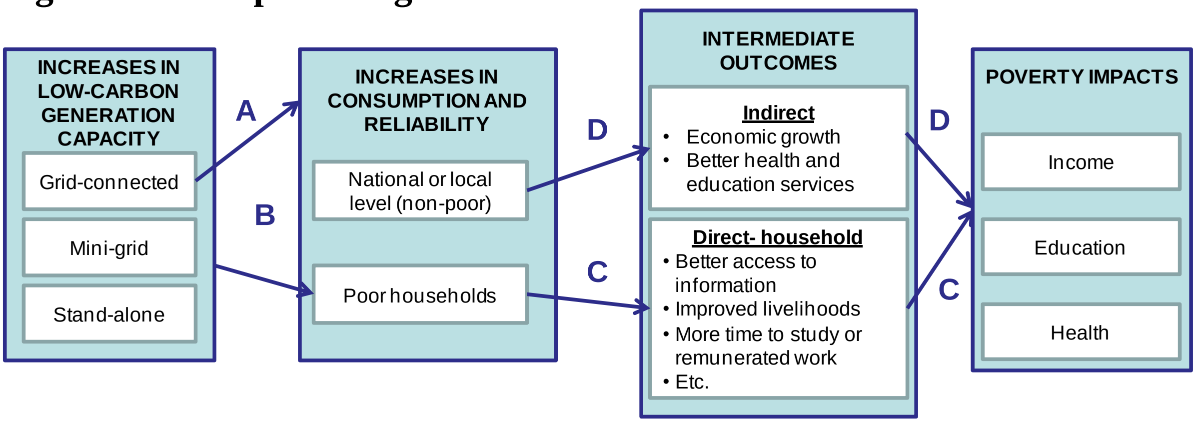
An increase in electricity supply, access and reliability will lead to economic growth only if other factors, including policies, are supportive of such growth – i.e. only if electricity is one of the key binding constraints on growth (UNDP 2012). If this were the case then we would expect to see positive results for the electricity-growth relationship in standard time series causality tests. In practice, different studies produce different results (e.g. Altinay and Karagol 2005; Shiu and Lam 2004; Ghosh 2002; Wolde-Rafael 2006), suggesting that other factors influence the electricity-growth relationship, and that it is important to identify assumptions made and include only studies that control for other factors.

The degree to which any wider growth effects benefit poor households depends on a large number of other factors affecting distribution, including policies and the institutional environment (for a recent review see Ferreira and Ravallion 2008: 20-24). The wider literature on the relationship between economic growth, distribution and poverty reduction is very large, and a detailed review of that literature is beyond the scope of this study. Our review will contain only a short summary of the key findings of the evidence to date, based on existing reviews of the literature.

A second set of spill-over effects may come from better health and education services because schools, clinics and hospitals get better access to reliable electricity supply (e.g. Modi *et al.* 2005). In health facilities, electricity facilitates services such as sterilisation, water supply and purification, sanitation, and refrigeration of essential medicines (GTZ and NL Agency 2010). Electricity in schools provides better lighting and allows the use of ICTs in teaching and learning (GTZ and NL Agency 2010: 12). However, one review (World Bank IEG 2008) finds no evidence for effects through these routes in rural areas (for instance in immunisation rates), and instead points to the effect that electricity provision increases the willingness of more-educated workers (such as teachers, doctors, nurses, and extension agents) to reside in rural areas.

The classification of potential routes from the addition of electricity generation to final poverty impacts is summarised in Figure 2.1 below. The figure shows how each of the questions (A-D) tries to address the links between electricity capacity and impacts on poverty.

Figure 2.1 Simplified logic model



3 Scope of the review and inclusion criteria

The general area of interest for the review is the developmental benefits of electricity. But to make the review feasible and to ensure that it contributes usefully to DFID's policy and programming, the boundaries and scope of the review need to be carefully spelled out. The relevant issues and options are briefly summarised below, together with proposed choices in each case.

3.1 Electricity systems

The scope of DFID's interest covers on-grid electricity, mini-grids and stand-alone systems. The latter categories are important because it is expected that they will play a major role in meeting universal access in sub-Saharan Africa and India by 2030, with 60-65 per cent of new generation occurring either in mini-grids or in stand-alone systems (IEA 2010). Decentralised electricity supply is most attractive in remote or sparsely settled areas where grid infrastructure is an expensive option, although Deichmann *et al.* (2011) emphasise that it is difficult to make generalisations because spatial factors vary so much between countries. While question A refers specifically to low carbon generation capacity, the rest of the questions will take into account the impact of electricity regardless of how it was generated. This is because electricity is a homogeneous service and its effects on poverty are expected to be similar regardless of the generation source.

3.2 Definition of 'poor' and 'non-poor' households

We are particularly interested in elements B to D above in identifying electricity consumption and direct or indirect benefits for poor people. However, different studies will define what constitutes 'poor' in different ways. We do not propose to use any particular definition of poverty to reject or accept studies, partly because there is no absolute basis for doing so. Rather, we will attempt to classify and group studies by their definition of poverty, to allow appropriate comparisons of results.

3.3 Geographical scope

Following the 2010 bilateral aid review, DFID has increased its focus on low-income countries. However, the purpose of this review is to learn from a wide evidence base in developing countries. At the same time, investments under the ICF may be considered in some middle-income countries as well as in LICs. Therefore we propose to consider evidence on the four areas above from all developing countries (i.e. low-income or middle-income countries, as defined by the World Bank).

3.4 Measurement of development benefits

There are many possible measures of the ultimate impact of electricity consumption on poor people. One study lists up to 50 discrete possible benefits.[18] As discussed below, electricity provision can in theory lead to impacts on poor people through both direct and indirect routes. In assessing the direct developmental benefits of electricity consumption, it is useful to distinguish between final impacts on poverty and the intermediate outcomes made possible by electricity.

Some studies focus on assessments of the intermediate outcomes of electricity, partly because it is easier to attribute a causal link, since final poverty outcomes depend on a far greater range of other factors. Dinkelman (2008), for example, examines the effects of electrification of rural communities on women's employment rates, the use electric lighting

[18] Saunier (1992) cited in World Bank IEG (2008)

and fuel wood use. Bernard and Torero (2009) assess the effects of connection on time allocation. GTZ and NL Agency (2010) include the benefits of electric lighting in terms of quality of light and exposure to smoke. However, some studies also include final outcomes. For example, Khandker *et al.* (2009a; 2009b) assess the impact of electrification on household income, expenditure and educational outcomes in Bangladesh and Vietnam.

There are a wide range of potential intermediate outcomes, including:

- Higher quality lighting than that from kerosene lanterns or candles, which can extend the day and allow children to study for longer (e.g. Barnes and Halpern 2000)[19].
- Lower long-term cost of electric lighting than using kerosene lanterns (GTZ and NL Agency 2010).
- Reduced exposure to smoke and free time previously spent on collecting biomass, where electricity displaces traditional biomass for cooking, with both outcomes especially affecting women and girls in most contexts (OECD 2006; GTZ and NL Agency 2010).
- New opportunities for employment and livelihoods through providing power for machinery (e.g. for pumping water for agriculture, food processing, apparel production, and light manufacturing) and for a range of appliances in small-scale service enterprises.
- Better access to information through increased use of ICTs, including mobile phones, radio, TV and internet.
- Safer food storage through access to refrigeration.

Specific impacts of the outcomes above on gender will be taken into account. A separation can also be made between productive and non-productive uses of electricity, including studies related to both households and industry.

Since the effects of electricity access may work through many potential routes, we propose to have an open approach to intermediate outcomes, and not exclude any studies on the basis of a fixed list of such indicators.

However, we do propose to have a set of three priority poverty impacts, as follows:

- increased net incomes;
- improved health outcomes, both in general and specifically for women and girls (measured in mortality, respiratory disease, immunisation rates, fire accidents, diseases related to hygiene in the house);
- improved educational outcomes and greater gender equity in education (OECD 2006).

Other final impacts will be grouped into an ‘other’ category. This is because of the importance of these three indicators, and the fact that many studies focus on them.

Increases in electricity provision can also provide benefits to poor people indirectly, for example through economic growth in the wider local or national economy, leading to higher incomes for the poor, or better public services. We therefore propose to include studies that take economic growth as an intermediate outcome of improved or expanded electricity provision. However, the relationship between economic growth and poverty reduction will not be analysed, as this falls out of the scope of the review.

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[19] However, Modi *et al*. (2005) note that electricity provision also allows access to television, which can be a distraction.

3.5 Time horizon

Studies on recent interventions will be given priority over studies based in interventions taking place in more remote periods of time. The definition of a limit year for inclusion of studies will be done once we are better informed about the availability of high-quality studies.

As regards the period of time within which outcomes and ultimate impacts of electricity provision are assessed, the longer the period, the greater is the potential for confusion between impacts due to changes in electricity provision and those possibly due to other factors. This would be the case at the level of a household or economy-wide. Studies will only be included if they have sufficient controls for such factors.

However, if a short period is chosen, there may not be sufficient time for the benefits of electricity access to be felt, even though they may be significant in the long term. A short time period also prevents assessment of the sustainability of the intervention and its impact. In addition, the time taken for different benefits of electricity consumption to be evident is likely to vary.

One approach would be to exclude any studies that assess outcomes or impacts before a minimum amount of time after electricity consumption begins (e.g. one year). However, any such minimum cut-off time frame would inevitably be rather arbitrary. Instead, we propose in the review to classify studies of effects on a particular outcome by the time period involved, partly to attempt to assess whether differences in effects may be due to the time period over which they are measured.

3.6 Methodological approach

We will use empirical studies (as opposed to descriptive, methodological or conceptual) that employ quantitative or qualitative data on outcomes and impacts.

For the quantitative analysis of poverty impacts of access to electricity, we will focus on studies that use appropriate counterfactuals and adequate controls. There are a number of attribution problems in assessing the impact of electricity provision (especially access) on outcomes at the household or village level (Bernard 2010). One is the need to control for other factors which may also have an impact on poverty, and that may be changing over the period during which access to electricity expands, or during which reliability improves significantly. Simple comparisons of households before and after gaining access to electricity will not distinguish between correlation and causality.

Comparisons between, on the one hand, households or villages that gain access to electricity and, on the other, those that do not also need caution, as differences in initial conditions may be in part responsible for outcomes. At both the household and the village level, the pattern of electricity access itself may be caused by differences in wealth or income. As discussed above, electricity is sometimes provided to wealthier communities as a priority, on the basis that returns from that access will be higher in such communities (placement bias). High connection fees may mean that at any one time those households which have access to electricity tend to be those that are wealthier (self-selection bias). Failing to correct for such biases may lead to overestimation of the impacts of the benefits of electricity.

Researchers only started to address these methodological issues relatively recently, with an ESMAP study of the Philippines in the early 2000s being the first study to control for self-selection bias (World Bank IEG 2008).

There are several possible ways of correcting for such biases. Placement bias at the community level can be avoided by the use of instrumental variable estimation (e.g. Dinkelmann's (2008) study in South Africa which uses land gradient as an instrument for electricity access). One project in Kenya is introducing access at the community in a randomised way to try to overcome placement bias and then comparing matched samples of households to tackle self-selection bias (Chemin and de Laat 2010). More widely, some studies tackle self-selection bias through difference-in-difference estimators on matched samples, comparing the evolution of outcomes between treated and control households, with fixed effects, as in Khandker *et al.*'s study of Vietnam (2009).

In the review we propose to take the following two-stage approach. All empirical studies assessing the outcomes and final impacts of access will be considered. Those which do not employ methodologies to correct for bias will be noted; their findings will not be discarded, but they will be somewhat discounted, and where possible the direction of bias in estimates of impacts will be identified. Those studies that do employ methods for correcting bias will be treated separately and their findings will form the main basis of any conclusions.

Assessing the relationship between electricity consumption and economic activity or growth at more aggregate levels (i.e. the local, regional, state or national level) also involves the methodological challenge of establishing causality. Typically, economic growth and growth in electricity consumption are quite highly correlated, but establishing causality running from electricity to economic growth, rather than the other way round, is not straightforward, and there are likely to be bi-directional feedback loops (UNDP 2012). Most studies employ some form of Granger causality test, and again, while studies producing correlations will be noted, only studies using such tests will be used to base conclusions on.

3.7 Language

We propose to include only studies in English.

4 Proposed search protocol [20]

4.1 Nature of the evidence base and types of studies

The evidence base will be assessed in four parts according to the four review questions provided in Section 4.

Question A will mostly be addressed by the parallel study by the University of Durham. We will support their exercise by analysing the extent and availability of data in developing countries on the state of networks, the reliability of electricity supply and the number of users. We expect evidence to come principally from national electricity authorities and will survey a sample of the websites of such authorities.

Question B, on the relationship between the extension of the grid and electricity consumption by poor households: we will seek evidence from two different sources. The first is evaluations of electrification projects undertaken by donors. We will contact multilateral and bilateral donors directly to request access to relevant evaluations. The second source is studies of electrification processes (especially in middle-income countries) in published journals and grey literature.

Questions C and D. We anticipate that significant literatures exist both in published journals and in grey literature, especially from the multi-lateral development banks. We will perform electronic searches to search and collect evidence to respond to these questions.

4.2 Databases and grey literature

The search will encompass both peer-reviewed studies and grey literature. We propose that the following databases will be used initially and will be added to and amended as appropriate:

Google Scholar
ISI Web of Knowledge
Elsevier Science Direct
WorldCat (Online Computer Library Centre)
Social Sciences Citation Index
IDEAS
International Bibliography of the Social Sciences
British Library for Development Studies (BLDS)
ELDIS
ProQuest Dissertations & Theses database (PQDT)
JOLIS
EconLit.

We will also conduct bibliographic back-referencing and citation tracking of included studies, especially of key surveys of the literature. In addition to this, we will include the literature provided to us by stakeholders suggested by DFID as part of the expert advisory group.

We will make sure that key grey literature is included, by searching in websites of key stakeholder organisations that may have relevant reports not indexed in the databases

[20] The approach taken here is based in part on similar reviews in the UK Energy Research Centre's Technology and Policy Assessments series

above, mainly the World Bank, the International Energy Agency, United Nations Development Programme (UNDP), Japan International Cooperation Agency (JICA), Australian Government Overseas Aid Program (AusAID), United States Agency for International Development (USAID), Asian Development Bank (ADB), Inter-American Development Bank (IDB) and other major bilateral and multilateral donors. We will approach donors directly to ensure that all relevant evaluation reports are included.

4.3 Search strings

The choice of search terms is crucial, and may need further revision after initial scoping. There is a need to balance the imperative of including all relevant literature with the need to keep the costs of the review within budget by minimising the probability of including irrelevant studies in the electronic search which then have to be manually excluded from the review.

To achieve these aims, the search design will be aligned with the sub-questions outlined in section 4 above. We propose to cover each sub-chain of the logic model with a set of search terms. These sets can be combined using logical operators such as AND or OR to construct search strings for use in electronic databases. The first set of search terms captures interventions to increase the access to electricity. The second set captures the direct results of those interventions as regards the actual use of electricity. The third set captures studies on different poverty outcomes of the increased use of electricity. The fourth and fifth sets aim at limiting the results to studies based in developing countries and dealing with low carbon technologies. Because electricity is a homogeneous service, regardless of the technologies used, we will not exclude studies that do not focus specifically on low carbon technologies.

Table 4.1 Search terms

Interventions	Uses	Poverty outcomes	Geography	Low carbon technologies
Electrification	Access	Poverty	Developing* countr*	Hydro
Electricity	Consum*	Poverty reduction	Southern countr*	Solar
Energy	Use	Poor households	Low income countr*	Wind
Generation	Demand	Benefits	Poor countr*	Renewable energ*
Capacity	Light* or illuminate*	Health	Underdeveloped countr*	Clean energ*
Network	Refrigerat*	Education	Sub-Saharan Africa	Biomass energy*
Grid	Heat*	Livelihood*	Africa	Energy efficien*
Mini-grid	Freez* or cool	Employment	South East Asia	Clean energy*
Stand-alone	Communication OR radio OR television OR TV or OR ICT OR internet	Gender	Latin America	Sustainable energy*
Extension	*phone charg*	Labour	China	
	Cook*	Development	India	
	Pump*	Econom*	Brazil	
	Food storage	Growth	(country	

			disaggregation)	
	Energy services	Income	Rural	
	Useful work	Wealth		
		Turnover		
		Productivity		
		Industr*		
		Study		
		Women		
		Girls		
		Information		
		Knowledge		
		Welfare		

We will conduct pilot searches to ensure that the results do not include irrelevant studies having similar words from other unrelated disciplines and exclude relevant studies. because they contain only synonyms of the keywords used here. The search terms will be changed according to the results of these pilot searches.

4.4 Selection of studies

Once the searches are complete, the review team will categorise studies for inclusion, logging decisions using appropriate software.

The first inclusion criterion applied will be relevance to the main subject of the review. Our assessment of relevance will be limited to titles, abstracts and keywords (where available) for papers in the above databases. We will use suitable options available in databases to focus the searches appropriately.

The inclusion criteria defined in section 4 will be applied successively to titles and abstracts and full reports.

Studies will be categorised into three groups: excluded; noted but methodologically incomplete; and included. Noted and included studies will then be coded and organised using an appropriate software package (e.g. EndNote).

The review team will then analyse the included studies, in relation to the research questions identified in section 3 above.

5 Data extraction

Table 5.1 shows the information that will be extracted from each included study. The contents of this table can be modified as we proceed with the literature review, after agreement with DFID.

Table 5.1 Data extraction

General information	Full bibliographic reference
Review question (s) addressed	a) Under what circumstances does investment in low carbon generating capacity increase the number of electricity consumers, the consumption of existing consumers or the reliability of supply? b) Under what circumstances does the extension of networks ('electrification') lead to more poor households consuming electricity? c) What are the poverty outcomes of poor households' electricity consumption? d) Do improvements in electricity supply lead to effects that can indirectly benefit poor households?
Publication type	Peer review journal article, institution working paper, multilateral development bank evaluation report, etc.
Geographical coverage	
Type and characteristics of intervention analysed	• Investments in electricity generation capacity in general • Investments in low carbon generation capacity (specify type). • Type of electricity system (On-grid, off-grid, stand-alone). • Grid extensions • Grid improvements • Etc.
Direct intermediate poverty outcomes considered	• Health • Education • Improved livelihoods • Employment • Study • Household productivity • Access to information • Other
Indirect intermediate poverty outcomes considered	• Economic growth • Productivity • Turnover • Other
Final poverty outcomes considered	• Income • Health • Education • Other
Gender effects	Yes/no
Sample characteristics	• Sample size • Country, region or cross-section • Period of study

	• Method for sample selection
Methodological approach	• Quantitative analysis (econometric, cost benefit analysis) • Qualitative case studies • For econometric methodologies provide estimator type, instrumental variables used as well as control variables.
Outcomes	• Quantitative research: quantification of direct, indirect, final or intermediate poverty outcomes for meta-analysis. • In econometric studies, extraction of standard errors, sample size, R2, confidence interval • Qualitative research: description of outcomes • Gender differentiation when available
General quality assessment	Provide a rating of high/medium/low quality based on the following factors. For quantitative studies: • Appropriate control groups • Representative samples • Ability to determine causal relationships • Specific definition and measurement of the poverty outcome • Clear measurement and control for confounding variables • Robustness checks • For qualitative studies • Credibility of findings • Breadth and depth of study findings • Extent to which the study addresses original aims and purposes • Defensibility of study design and sample design and coverage • Quality of the approach and formulation of the analysis • Clarity and coherence of reporting • Clarity of assumptions that have shaped the form and output of the study

6 Data synthesis

The process of synthesis is structured according to the review questions as detailed in section 3 and illustrated by Figure 2.1. We propose to conduct a realist review that addresses the fact that often the same interventions have different outcomes in different contexts.

The literature will be classified according to the four necessary steps required to answer the main review question: under what conditions does adding low carbon electricity generation capacity (both on and off-grid) lead to development benefits for poor people?

1. Establish links between increased low carbon capacity and increased number of electricity consumers, the consumption of existing consumers or the reliability of supply. These links will be provided by the results of power systems planning models used to explore the expected outcomes of investments in new generating capacity in particular systems in particular countries. A simple assessment methodology is being developed by Dr Chris Dent, School of Engineering and Computer Sciences at the University of Durham, in a parallel exercise to this review. IDS will support this assessment by reviewing the availability of data in developing countries as required by Dr Chris Dent.

2. Establish links between electrification (access) and increased electricity consumption by poor households. We will synthesise the evidence about the relationship between the provision of access to electricity to poor households and their actual consumption. Quantitative information will be synthesised as well as the factors that influence the increased use of electricity.

3. Establish links between increased electricity consumption and poverty outcomes. Literature on poverty outcomes will be classified per the intermediate or final poverty outcome analysed. Gender will be treated as a cross-cutting dimension.

4. Establish links between increased electricity supply and benefits for the economy that can have an indirect effect on poverty (i.e. economic growth). A quantitative meta-analysis of the impacts of electrification on economic growth or other indicators will be performed if a number of conditions are met, as described in the previous paragraph. The subsequent impact of economic growth on poverty alleviation will be based in existing reviews, as an in-depth review of that relationship is beyond the scope of this study.

A quantitative meta-analysis for the outcomes of literature addressing questions 2 to 4 will be possible if we find a significant number of quantitative studies that comply with the inclusion criteria, report one or more effect sizes on poverty outcome measures, share the same methodology and a homogeneous context. All the quantitative results will be presented in a summary table which will include information on the geographical context, type of intervention, control factors and other methodological issues. When possible, we will provide a gender dimension for all the poverty outcomes.

The synthesis of the data will identify the assumptions made in the different studies and argue the reasons for the different conclusions reached. It will also highlight the methodological challenges to accurate estimation of impacts, and their solutions.

The conclusions of the report will identify the existing gaps in the literature and suggest further areas of research.

7 Workplan

Figure 7.1 Workplan

	Oct	Nov	Dec	Jan	Feb	Mar	April	Outputs
Final protocol submitted								Deliverable 1
Searches								
Screening								
Data extraction								
Synthesis								
Writing of main review - first draft								
Review first draft								
Final draft								Deliverable 2
Presentations								

8 Expert advisory group

The review will be advised by a group of experts from a range of organisations, who will provide comment on both a draft of this note, and of the review itself. The group comprises:

> Jiwan Acharya, Asian Development Bank
> Rob Byrne, Sussex Energy Group, Science and Technology Policy Research Unit (SPRU), University of Sussex
> Héla Cheikhrouhou, Director, Energy, Environment and Climate Change Department, African Development Bank
> Simon Desjardins, Programme Manager - Access to Energy, Shell Foundation
> Carsten Hellpap, Program Director, Energising Development, GIZ

The review team welcomes suggestions from DFID of further experts to join this group, including experts from the power sector.

Annex 1: Generating capacity, access and reliability of supply

The net impact of adding new generating capacity to an underpowered network will depend on two factors. The first is how demand is changing. The capacity margin (M) is equal to the excess of de-rated peak capacity (Cp) over total peak demand (Dp):

$$M = Cp - Dp$$

and total peak demand can be expressed as the product of the number of users (N) and average peak demand :

$$M = Cp – (N*dp), \text{ where } dp = Dp/N.$$

An addition to generating capacity should provide some combination of improvement to reliability of supply (i.e. increase in M), greater access (i.e. increase in N) or increased peak consumption of electricity per user (i.e. increase in Dp), as long as that addition exceeds any increase in peak demand, i.e. as long as:

$$\Delta Cp > \Delta Dp = \Delta N * \Delta dp$$

Because the relationship between capacity margins and reliability (for example, measured by loss of load probability) is non-linear, the net effect on system reliability of adding a certain amount of new capacity in any given case will depend on the existing level of margin. Investing new capacity can be expected to have the most dramatic effects on improving reliability where the capacity margin is negative, zero or very low, and less effect where the existing margin is in the range 10-15 per cent. As noted, the type of capacity added also matters, as intermittent renewable power sources will be de-rated more than conventional thermal plant.

Annex 2: Review team

The review team consists of Ana Pueyo and Xavier Cirera, Research Fellows at the Institute of Development Studies, assisted by a Research Officer

This scoping note has been prepared by Matthew Lockwood, Research Fellow at the Institute of Development Studies and Climate Change Team Leader up until October 2012, with input and advice from Ana Pueyo and Xavier Cirera.

Ana Pueyo will be primarily responsible for managing the project from October, will lead the search and review itself, oversee the analysis and the report drafting. Xavier Cirera will provide advice and quality assurance. A Research Officer will be involved in performing the searches, assist with screening, data extraction and draft parts of the report.

A complementary exercise on developing a simple checklist methodology for assessing the potential for investments in low carbon generating capacity to provide more poor households with reliable electricity supply is being undertaken by Dr Chris Dent of the University of Durham, based on power system modelling.

References

AEA Technology (2003) *Energy to Reduce Poverty: A Report Produced for the Department for International Development,* London: Department for International Development

Altinol, G. and Karagol, E. (2005) 'Electricity Consumption and Economic Growth: Evidence from Turkey', *Energy Economics* 27: 849–856

Asian Development Bank (ADB, 2009) *Bangladesh: Meghnaghat Power Project* [Loan 1793] Evaluation Report, http://www.adb.org/documents/bangladesh-meghnaghat-power-project-loan-1793 (accessed 20 July 2013)

Asian Development Bank (ADB, 2010) *Assistance for Rural Electrification in Bhutan – Does Electrification Improve Quality of Rural Life?* Manila: Asian Development Bank

Ayres, R. and Warr, B. (2005) 'Accounting for Growth: the Role of Physical Work', *Structural Change and Economic Dynamics* 16, 2: 181-209

Barnes, D. and Halpern, J. (2000) *Subsidies and Sustainable Rural Energy Services: Can We Create Incentives Without Distorting Markets?* Energy Sector Management Assistance Programme Technical Paper 010, Washington DC: World Bank

Bernard, T. (2010) 'Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa*', World Bank Research Observer* 27.1 http://elibrary.worldbank.org/content/article/1564-6971-27-1-33-51 (accessed 20 July 2013)

Bernard, T. and Torero, M. (2009) *Impact of Rural Electrification on Poorer Households in Ethiopia*, Washington DC: World Bank

Birol, F and Brew-Hammond, A. (2012) Sustainable Energy for All: Technical report of Task Group 1 http://bit.ly/1arK6Wj

Brenneman, A. and Kerf, M. (2002) 'Infrastructure & Poverty Linkages: A Literature Review' http://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/---invest/documents/publication/wcms_asist_8281.pdf (accessed 20 July 2013)

Chemin, M. and De Laat, J. (2010) 'The impact of rural electrification on poverty: evidence from a randomised experiment in Kenya', unpublished

Clancy, J.; Matinga, M.; Oparaocha, S. and Winther, T. (2011) *Gender Equity in Access to and Benefits from Modern Energy and Improved Energy Technologies* World Development Report Background Paper, http://www.norad.no/en/thematic-areas/energy/gender-in-energy/_attachment/385686?_ts=13356322c17 (accessed 20 July 2013)

Committee on Electricity in Economic Growth, Energy Engineering Board, National Research Council (1986) *Electricity in Economic Growth,* Washington DC: The National Academies Press

Cook, C.; Duncan, T.; Guobao, W.; Jitsuchon, S. and Sharma, A. (2005) *Assessing the Impact of Transport and Energy Infrastructure on Poverty Reduction,* Manila: Asian Development Bank

Deichmann, U.; Meisner, C.; Murray, S. and Wheeler, D. (2011) 'The Economics of Renewable Energy Expansion in Rural sub Saharan Africa', *Energy Policy* 39: 215-227

Dinkelmann, T. (2008) *The Effects of Rural Electrification on Employment: New Evidence from South Africa,* Population Studies Center Research Report 08-653

Ferreira, F. and Ravallion, M. (2008) *Global growth and inequality: a review of the evidence* Policy Research Working Paper 4623, Washington D.C: World Bank

Ghosh, S. (2002) 'Electricity consumption and economic growth in India', *Energy Policy* 30, 2: 125-129

Golden, M. and Min, B. (2012) *Theft and Loss of Electricity in an Indian State,* Working Paper 12/0060, International Growth Centre, http://www.theigc.org/sites/default/files/golden_and_min_paper.pdf (accessed 20 July 2013)

Gesellschaft für Technische Zusammenarbeit (GTZ) and NL Agency (2010) *Energizing Development: Report on Impacts,* Eschborn, Germany: GTZ and SenterNovem

International Energy Agency (IEA, 2010) *World Energy Outlook 2010,* Geneva: IEA

Jahan, S. and McCleery, R. (2005) *Making Infrastructure Work for the Poor: Synthesis Report of Four Country Studies – Bangladesh, Senegal, Thailand and Zambia,* New York: UNDP

Khandker, S., Barnes, D. and Samad, H. (2009a) *Welfare Impacts of Rural Electrification: A Case Study from Bangladesh* Policy Research Working Paper 4859, Washington DC: World Bank

Khandker, S. *et al*. (2009b) *Welfare impact of rural electrification: Evidence from Vietnam* World Bank Policy Research Working Paper 5057, Washington DC: World Bank

Modi, V.; McDade, D.; Lallement, D. and Saghir, J. (2005) *Energy Services for the Millennium Development Goals,* London/Washington DC: World Bank/UNDP

Norwegian Agency for Development Cooperation (NORAD, 2008) *Impact Assessment of Norad-funded Rural Electrification Interventions in Northern Nambia*, *1990-2000,* http://www.norad.no/en/tools-and-publications/publications/publication?key=109774 (accessed 20 July 2013)

Organisation for Economic Cooperation and Development (OECD, 2006) *Promoting Pro-Poor Growth: Infrastructure*, Paris, France: OECD Publications

Organisation for Economic Cooperation and Development/International Energy Agency (OECD/IEA 2010) *Energy Poverty – How to Make Modern Energy Access Universal? Special Early Extract of the World Energy Outlook 2010 for the United Nations General Assembly on the Millennium Development Goals*, https://www.iea.org/publications/freepublications/publication/weo2010_poverty.pdf (accessed 20 July 2013)

Pan, J; Chi Z.; Elias, R.; Li, M.; Peng, W.; Victor, D.; Wan L.; Wu X. and Zerriffi, H. (2006) *Rural Electrification in China 1950-2004: Historical Processes and Key Driving Forces,* Working Paper #60, Stanford, California: Program on Energy and Sustainable Development

Practical Action (2010) *Poor Peoples' Energy Outlook 2010,* Rugby: Practical Action Publishing

Practical Action (2012) *Poor Peoples' Energy Outlook 2012*, Rugby: Practical Action Publishing

Prud'Homme, R. (2005) 'Infrastructure and Development', in F. Bourginon, and B. Pleskovic (eds), *Lessons of Experience: Annual World Bank Conference on Development Economics 2005*, Washington DC: World Bank

Saunier, G. (ed) (1992) *Rural Electrification Guidebook for Asia and the Pacific,* Bangkok: Asian Institute of Technology

Shiu, A. and Lam, P-L. (2004) 'Electricity Consumption and Economic Growth in China'. *Energy Policy* 32, 1: 47-54

Straub, S. (2008) *Infrastructure and Development: A Critical Appraisal of the Macro Level Literature,* World Bank Policy Research Working Paper 4590, Washington DC: World Bank

Suarez, C. (1995) 'Energy Needs for Sustainable Human Development' in Goldemberg, J. and Johansson, T. B. (eds) *Energy as an Instrument for Socio-economic Development,* New York: United Nations Development Programme

United Nations Development Programme (UNDP, 2012) *Integrating Energy Access and Employment Creation to Accelerate Progress on the Millennium Development Goals in Sub-Saharan Africa,* New York: United Nations Development Programme

Unruh, G. (2006) 'Globalising carbon lock-in', in *Energy Policy* 34, 10: 1185-1197

Willoughby, C. (2002) *Infrastructure and Pro-poor Growth: Implications of Recent Research* Report by Oxford Policy Management for DFID

Winther, T. (2008) *The Impact of Electricity: Development, Desires and Dilemmas,* Oxford/New York: Berghahn Books

Wolde-Rafael, Y. (2006) 'Electricity Consumption and Economic Growth: A Time Series Experience for 17 African Countries' in *Energy Policy* 34, 10: 1106-14

World Bank (1995) *Rural Electrification: A Hard Look at Costs and Benefits*, Washington DC: World Bank.

World Bank Operations Evaluation Department (1995) *Rural Electrification: A Hard Look at Costs and Benefits,* Washington DC: World Bank

World Bank (2009) *Africa's Infrastructures: A Time for Transformation,* Washington DC: World Bank

World Bank Independent Evaluation Group (IEG) (2008) *The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits,* Washington DC: World Bank

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